Autonomous Inspection System

MOUNTAIN STATE INFORMATION SYSTEMS, INC.

MISSION MOUNTAIN TECHNOLOGY ASSOCIATES

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Systems & Software Technology Conference

Paul D. Garnett, President
619 W. Columbia Ave., Sunset #1
P.O. Box 3738
Telluride, CO 81435

(304) 367-0500: Fairmont, WV Office
(970) 728-1972: Colorado Office
(970) 708-7723: Cell
pgarnett@msisinc.com

Fred A. Palma
10240 Melbenji Ct.
Elk Grove, CA 95757

916 501-6051
Mountain State
  Information Systems, Inc.
fpalma@msisinc.com

Cody A. Benkelman
100 Second St. East
Suite 204
Whitefish, MT 59937

406 270-1176
Mission Mountain
  Technology Associates
cody@MissionMtnTech.com

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PREFACE

- ❖ Autonomous Inspection System that can circumnavigate an entire human-rated spacecraft
  - ➢ Same concept for Hovering Mini UAV and inspections of aircraft, buildings, bridges, roads, etc.
  - ➢ May possibly be expanded with UUV for ship hull inspections
- ❖ 2D / 3D Imaging System that can capture high resolution 5D images
- ❖ Integration with COTS CAD Systems
- ❖ Automated image inspection of As-Is and Baseline data

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AGENDA

I. **Preface**

II. **Agenda**

III. **Initiative** – Background

IV. **Previous Programs** – AerCAM, COTS CAD

V. **Objectives** – Technical / Programmatic

VI. **System Overview** – How is our Solution Different?

VII. **Key Technology** – Components to Success

VIII. **Potential Commercial Applications** – Bridges and Major Structures, Aircraft Fatigue, Road Inspection

IX. **Potential Military Applications**

X. **Go Forward Strategy** – Phase I

XI. **Current Efforts** – Next steps

XII. **Questions**

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BACKGROUND

❖ Columbia Accident Investigation Report, Vol. I, August 2003, Part One:

➢ R3.3.1 – "… implement a **comprehensive inspection plan**…"

➢ R6,4-1 – "… **develop a comprehensive autonomous (independent of Station) inspection** …"

➢ R3.4-3 – "… capability to obtain and **downlink high-resolution images** …"

➢ R10.3.1 – "… **Digitize the closeout photograph** system so that images are immediately available for **on-orbit troubleshooting**."

➢ R10.3.2 – "… **Converting all drawings to a computer-aided drafting system** …"

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AIS - AerCAM

❖ Miniature Autonomous Extravehicular Robotic Camera

➢ Dr. Steven E. Fredrickson: Automation, Robotics, and Simulation Division / ER6 NASA Johnson Space Center

➢ Designed:

   ▪ Remotely Piloted & Autonomous Operations

   ▪ Equipped with 2 Video Imagers

   ▪ 1 High Resolution Still-Frame Imager

   ▪ Dimension: 7.5" diameter

   ▪ Weight: 11 lbs

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MANUFACTURING – COTS CAD

❖ Current State:

➢ CAD systems have capabilities to design & model 3D components

➢ CAD systems have capabilities to detect "dimensional collisions" during model design

❖ Desired Enhancements:

➢ Import feature of 3D Mesh Data

➢ Automated Live and Baseline Image data analytics and reporting

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TECHNICAL / PROGRAMMATIC

- ❖ Operational Concept:
  - ➢ An Autonomous System that can detect external surface changes (damage) to current and future human-rated spacecraft during flight using 2D / 3D imaging systems
  - ➢ Decrease the physical inspection processing time by systematically detecting and reporting attribute changes of an object

- ❖ Technical Objective:
  - ➢ Develop a high resolution 5D imaging module for Autonomous Inspection Systems that can detect and report changes from a baseline set of images and/or CAD data base

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TECHNICAL / PROGRAMMATIC

❖ Inspection Accuracy:

➢ Higher level of image detail not easily seen by human eye

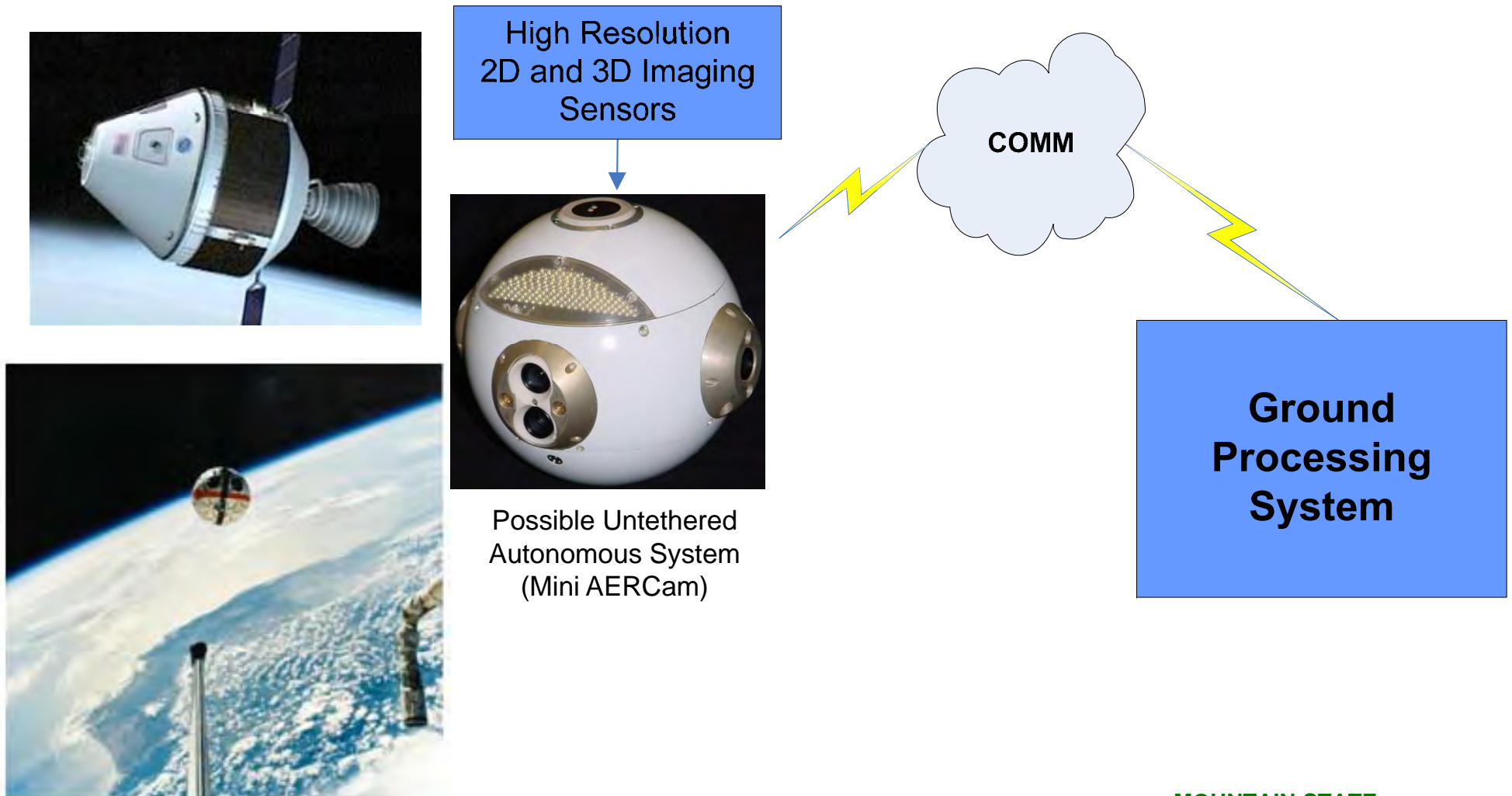➢ 3 Dimensional measurements for higher accuracy

❖ Inspection Efficiency:

➢ Automation in identifying physical damage to a specific targeted area of the spacecraft

➢ Automation in reporting dimensional discrepancies and out-of-tolerance features

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SPACECRAFT IN-FLIGHT INSPECTION SYSTEM

Video Example

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CONCEPTUAL DESIGN

High Resolution
2D and 3D Imaging
Sensors

COMM

Possible Untethered
Autonomous System
(Mini AERCam)

**Ground
Processing
System**

Provisional Patent Application Filed

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CONCEPTUAL DESIGN
(GROUND PROCESSING SYSTEM)

System Overview

2D/3D Front-end User Interface Application & Controls

2D/3D Image Capture / Reconstruction	**Robotic Camera Positioning / Location Controls**	2D/3D Camera Configuration Controls	2D/3D Image Quality Control	**2D/3D Image Analysis**	**Exception Reporting**

Middleware , BioAPI, SDK's

New SDK CAD / Baseline Integration

CORE TECHNOLOGY

Core 3D Image Capture & Reconstruction Algorithm	**Core 2D Image Capture & Reconstruction Algorithm**	**Core 2D/3D Object Analysis Algorithm**

Legend

New App

Existing Technology

Captured 2D/3D Images

CAD / Baseline Image DB

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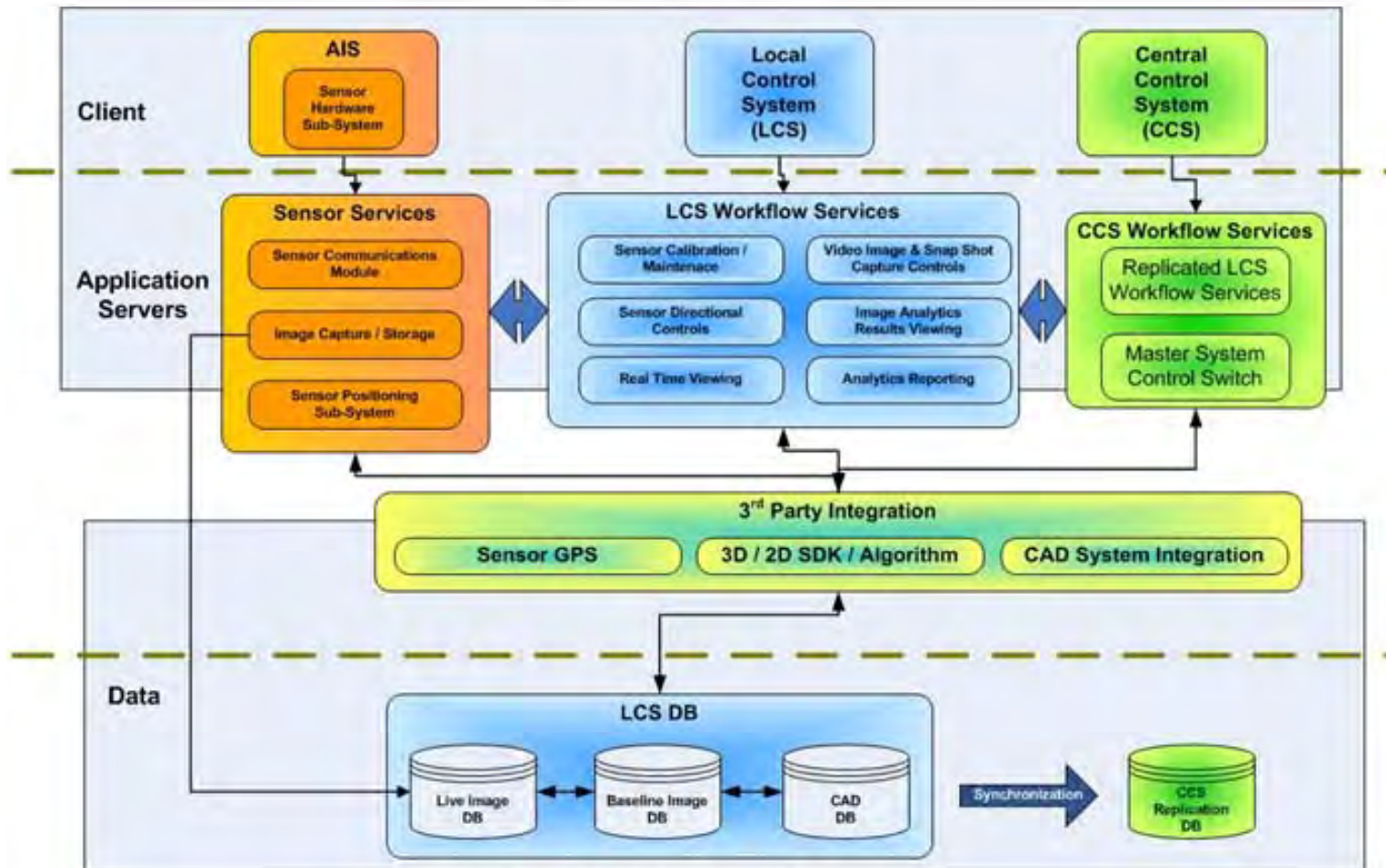
Provisional Patent Application Filed

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CONCEPTUAL DESIGN

AIS Application Software Architecture Design

Rev. 1.021910

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Provisional Patent Filed

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# *HOW IS OUR SOLUTION DIFFERENT?*

- ❖ Combines 2D & 3D Imaging Technologies
    - ➢ Modular Sensor Design (flexibility)
    - ➢ 3D – Higher level of detail
        - • Near Infrared Technology
        - • Structured Light
    - ➢ 5D = 3D with Texture for human eye viewing
- ❖ Integrate with existing COTS CAD vendors
- ❖ Higher accuracy in detecting dimensional discrepancies
- ❖ Faster reporting of damaged parts through automation of data analytics
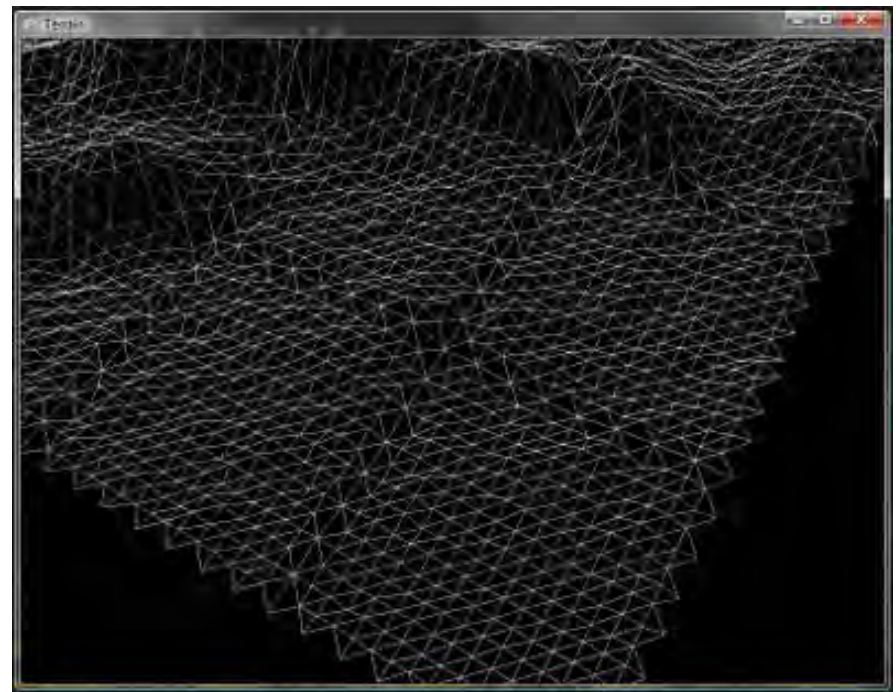
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2D + 3D = 5D
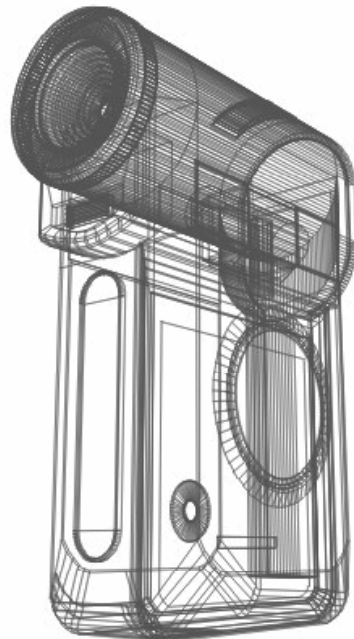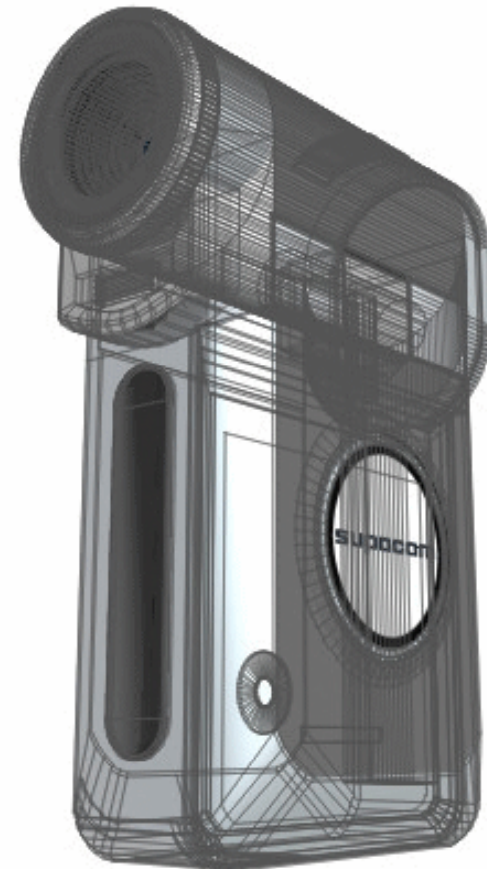
COMPONENTS TO SUCCESS

❖ Core Technology:

➢ Combination of high resolution imaging sensors to make 5D model

➢ Stitching algorithm of synchronized 2D and 3D image capture (US Patent #6,694,064)

➢ Systems integration with COTS CAD products

➢ Automation of live image and stored image dimension comparison, analysis and reporting
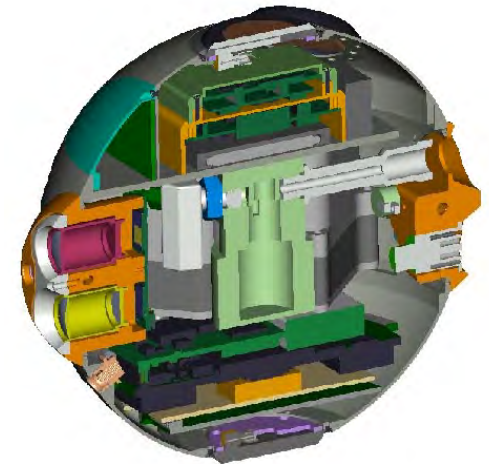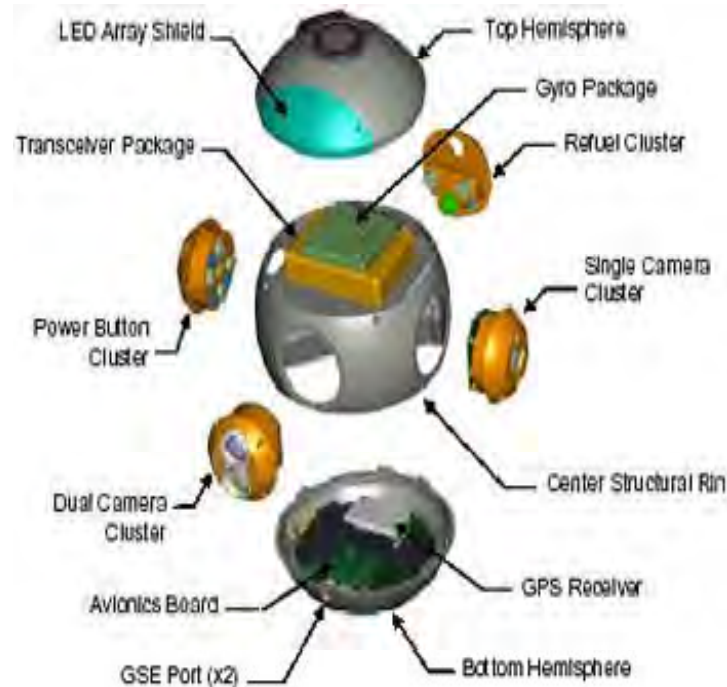

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COMPONENTS TO SUCCESS

❖ Technology Development:

➢ Mechanical Integration Design of Core Technology with an AIS

➢ Mechanical Development of 5D Sensor

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COMPONENTS TO SUCCESS

❖ Technology Development:

➢ Software Integration with existing COTS CAD

➢ Image Data Analytics and Reporting

➢ SDK Development

❖ Key Technical Expertise:

➢ 3D Imaging Systems

▪ Structured Light

▪ Near Infrared Light Source

➢ 2D and 3D Image Stitching

➢ System Architecture and Integration Design

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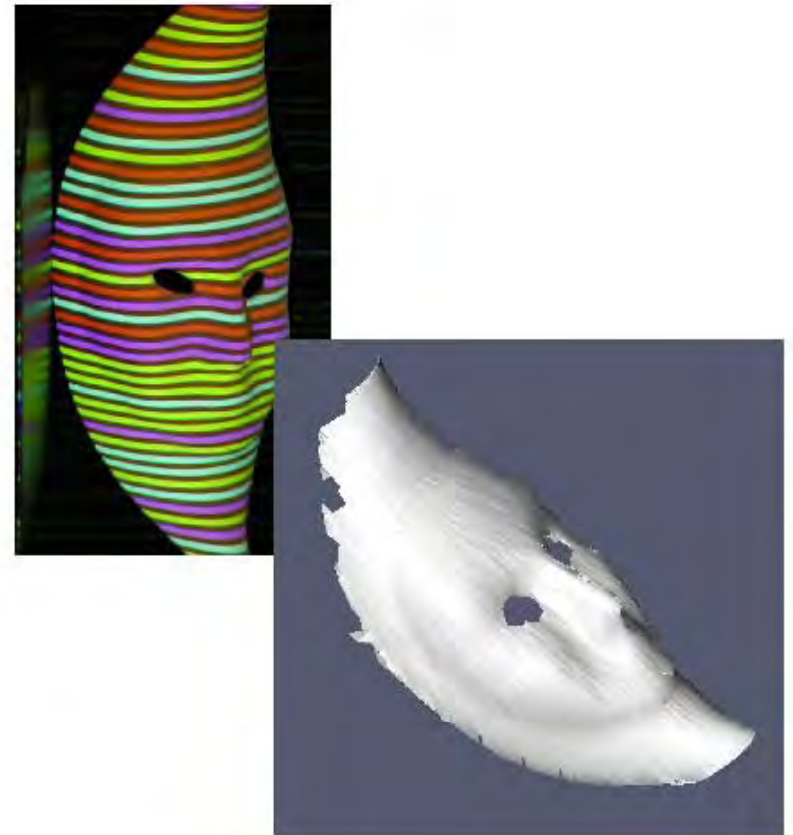
BRIDGES AND MAJOR STRUCTURES

❖ Current Inspection:

  ➢ Treacherous

  ➢ Manual Photos

  ➢ Expensive Equipment

❖ Impact to Quality of Inspection:

  ➢ Vision of Inspector

  ➢ Experience

  ➢ Wellness of Inspector

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BRIDGES AND MAJOR STRUCTURES

❖ DraganFlyer™ X6*:

➢ 6 Rotor Design

➢ Camera Mounting Brackets

➢ Counter Rotating Blades for Stabilizers

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* Draganfly Innovations Inc.

AIRCRAFT FATIGUE / DAMAGE

❖ Current Inspection:

➢ Visual Inspection

➢ Using sense of touch of the hand

➢ Mirrors, optical micrometers

❖ Impact to Quality of Inspection:

➢ Vision of Inspector

➢ Experience

➢ Wellness of Inspector

Arrows indicate crack in attach angle

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MILITARY APPLICATIONS

❖ Scan Roads for IEDs

➢ Provide additional solution, either better than current solutions or used to augment current solutions

➢ Potential Platforms (Mini Hovering UAV, Fixed Wing UAVs)

➢ Take images of roadways

▪ Compare today vs. yesterday

▪ May not be applicable to all scenarios (city [clutter] vs. dirt road in unpopulated area)

❖ Search buildings, vehicles for IEDs (Ground Robotics)

❖ Generate 3D representations of interior and exterior spaces

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PHASE I

❖ Business / Analysis

  ➢ Pursue other government opportunities

  ➢ Continue due diligence on previous AIS efforts

  ➢ NASA Return to Flight Task Group Final Report – Resolution of CAIB recommendations: Possible additional follow-up

    ▪ **Update of CAD Data Base - satisfactory**

    ▪ **Automation – incomplete**

    ▪ **"Continued vigilance urged…"**

  ➢ Continue with 2D and 3D Best-of-Breed technology evaluation

  ➢ Continue with COTS CAD evaluations

  ➢ Develop Sub-System marketability business case for commercial applications

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PHASE I (CONT.)

- ❖ Development

  - ➢ Complete System Integration Design

  - ➢ Complete High-level Software Architecture

  - ➢ Development of Tripod Prototype:

    - ▪ Develop 2D and 3D imaging sensors

    - ▪ Develop algorithm for 3D image capture, stitching, & reconstruction

    - ▪ Develop Synchronized Stitching Algorithm of 2D and 3D images

    - ▪ Test

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CURRENT EFFORTS

- ❖ Effort started in July '09

- ❖ Provisional Patent Development & Filing

- ❖ Establish Strategic Relationships with Initial Customer

- ❖ Determine funding source(s)

- ❖ Submitted informal proposal to NASA

- ❖ Discussions held and abstract submitted to an NSWC Dahlgren division

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TAKEAWAY MESSAGES

- ❖ Technologies Exist:
  - ➢ Host Platforms are available
  - ➢ High resolution 2D and 3D imaging systems are available
- ❖ Our System
  - ➢ Integrated 2D / 3D Imaging System to capture **high res 5D** images
    - ▪ **Near Infrared**
    - ▪ **Structured Light**
    - ▪ **2D and 3D Image Stitching**
  - ➢ To integrate with existing commercial COTS CAD systems
  - ➢ Automated image inspection to compare As-is (live) and Baseline data
- ❖ **Goal: Provide fast, high resolution inspections**

Paul Garnett
970 708-7723
pgarnett@msisinc.com

Cody Benkelman
406 270-1176
cody@MissionMtnTech.com

Fred Palma
916 501-6051
fpalma@msisinc.com

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